REMARKS

Reconsideration and allowance of the above referenced application is respectfully requested.

Claims 1-14 are currently pending in the present application. Claim 10 has been withdrawn from further consideration. Claim 1 is amended to more clearly define the present invention. The amendment of Claim 1 is fully supported by the specification and claims as originally filed. In particular the Examiner is directed to the specification at page 10, lines 1-13 and page 11, line 16 through page 12, line 12. No new matter has been added.

Rejections Under 35 U.S.C. § 103(a)

Claims 1-9 and 11-14 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Sato et al. (U.S. Patent No. 4,206,080) in view of Burnham et al. (U.S. Patent No. 5,997,812), further in view of Wieser-Linhart (U.S. Patent No. 5,762,662). By the above amendment to the claims, Applicants assert that the rejection is overcome.

The invention as now claimed is drawn to a method for treating a contaminated fluid, wherein the contaminated fluid has at least one soluble contaminant that is adsorbed onto a cellulose-based material as the contaminated fluid is passed through a column containing the cellulose-based material. When the cellulose-based material is spent, it is removed from the column and composted to reduce the volume of the material and to concentrate the at least one adsorbed contaminant.

Claim 1 has been amended to more clearly define the present invention as being directed to an adsorption process for the removal of at least one soluble contaminant. This amendment is consistent with the claimed adsorption process and Applicants' earlier submitted arguments. In contrast, the cited prior art references of Sato et al., Burnham et al., and Wieser-Linhart, are

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directed only to free or emulsified oil contaminated fluids; that is contaminants that are <u>not in solution</u> and are removed from a contaminated liquid by an absorption processes; not an adsorption process.

In the above referenced Official Action, in the last paragraph of page 3, the Examiner proposes a definition of adsorption, which is a limited definition that provides only a partial characterization of the adsorption process. The definition posed by the Examiner in the Official Action is that adsorption is the treatment of a fluid wherein the contaminant is retained on the surface of the adsorbent. While the Examiner-provided definition is, in a limited way, correct and may seem acceptable to a person unskilled in the art, it is only a partial definition of adsorption when considered by one of ordinary skill in the art. As earlier argued by Applicants, a more complete definition of adsorption, as understood by one skilled in the art, is particularly important to an accurate understanding of the references which have been cited in the Official Action. The references cited by the Examiner have repeatedly misused the term adsorption so as to confuse it with the absorption process that is actually described in the cited references.

To assist the Examiner in this matter, Applicants herewith provide as Attachment (1), a publication, which includes a discussion of the meaning of the term "adsorption." This attached discussion provides a more complete definition of adsorption as it is understood and used by those having ordinary skill in the art. In addition, the attachment concludes with a list of references which are also directed to the distinct process of adsorption. The discussion of the "Adsorption Phenomena" was obtained from the Internet and downloaded on February 4, 2004 from a web site accessible at http://ias.vub.ac.be/General/Adsorption.html. (pp. 1-6) The entirety of the down-loaded discussion has been copied and is attached hereto for entry into the application file for education purposes only. The attached discussion is directed to the question: "What is adsorption?" It is important to notice in the first paragraph of the discussion that a

-5-

complete definition of adsorption not only goes beyond the Examiner-provided definition of "adsorption" as simply relating to contaminants that are retained on the surface of the adsorbent, but actually points out that the principle distinction of adsorption is that it relates to removing soluble contaminants from solution. That is precisely the point of Applicants' earlier arguments, which distinguished the present invention from the methods of the cited prior art. The attached discussion makes it very clear, beginning with the first sentence on page 1, that adsorption is a process for the removal of "substances from either gaseous or liquid solutions." (Emphasis added). The second sentence of the discussion is equally clear in its meaning, stating, "This process known as adsorption, involves nothing more than the preferential partitioning of substances from the gaseous or liquid phase onto the surface of a solid substrate." Thus, while depositing a material on the surface of a substrate is a part of the definition of adsorption, it remains that, to one of ordinary skill in the art, the term adsorption more importantly relates to and must include the removal of substances from a gaseous or liquid **solution**.

As an additional reference, Applicants refer the Examiner to Attachment (2), which is an excerpt taken from page no. 19-33 of Chemical Engineer's Handbook, 5th Ed., Perry, Robert, Consultant; Chilton, Cecil Senior Advisor, McGraw-Hill, New York, NY, ISBN 0-07-049478-9, which states, "...adsorption, in which solute molecules are attracted to vacant sites on the surface of a microcrystalline or resinous sorbent, condensing on these sites by virtue of physical forces or chemical bonding." (Emphasis added) This excerpt from the Chemical Engineer's Handbook clearly defines the adsorption process as being directed to the removal of "solute molecules." Without question, a solute by definition is a soluble substance dissolved in solution.

A third reference is provided as Attachment (3), Environmental Engineering, Davis, Mackenzie; Cornwell, David, McGraw-Hill, New York, NY, ISBN 0-07-015918-1, at page 249, which states, "Adsorption is a mass transfer process wherein a substance is transferred from the

liquid phase to the surface of a solid, where it is bound by chemical or physical forces."
(Emphasis added) Here also, the transfer "from the liquid phase" clearly means the removal of a
solute from a solution. It could not possibly mean the removal of one liquid (oil) from another
liquid (water), as is the case in the cited prior art references.

A fourth reference is provided as Attachment (4), Granular Activated Carbon for Water
and Wastewater Treatment, CARBTROL Corp. brochure, Sept. 1992, Revised October 1992,
Tech. Paper -3 at the first page of the brochure. ,which states, "Adsorption is a natural process by
which molecules of a dissolved compound collect on and adhere to the surface of an adsorbent
solid." (Emphasis added) A "dissolved compound" clearly is a solute in a solvent.

Each of the defining references, discussed above as Attachments 1-4, agree with the
Examiner's definition in that a substance is deposited on the surface of an adsorbent material.
More importantly, each of the four Applicant-provided references are in agreement with the
Applicants' argument that one of ordinary skill in the art recognizes the principle characterization
and complete definition of adsorption lies in providing a process for removing a soluble
substance from solution and depositing the same on the surface of a solid. As evidenced by the
four attachments provided herewith, this is the complete definition of adsorption as it is known to
one skilled in the art. It clearly requires that the substance, which is deposited on the surface of
the adsorbent material is a soluble substance (a solute) that is removed from solution by the
adsorption process. In contrast, the prior art references cited in the Official Action, are directed
to free and distinct liquids or "emulsions," and, as such, are excluded from the definition of
adsorption at it is known to those skilled in the art.

Further, the descriptions of the prior art oil and water emulsions are consistent with the
term "emulsion" as defined by Webster's Desk Dictionary 1993, Steinmetz, Sol, Exec. Ed.,
Braham, Carol, Proj. Ed. Random House, ISBN 0-517-18198-3 at page no. 146, (Attachment

(5)), which defines emulsion as "a colloidal suspension of one liquid within another" or as described by the Chemical Engineer's Handbook, 5th Ed., at page 21-11, as "oil in water (organic dispersed, aqueous continuous)" See Attachment (6). According to the definitions provided by the Applicants and well known to those of ordinary skill in the art, the cited prior art references being directed to separate phase or oil and water emulsions are not the subject matter of an adsorption process and are not directed to removing soluble contaminants.

This distinction between adsorption and absorption has been the essence of Applicants' earlier arguments in which Applicants have pointed out that the claimed invention, which is an adsorption process, deals with contaminants that are soluble and are removed from solution to be deposited on the surface of the adsorbent material while the cited prior art references are all oil and water emulsions which have nothing to do with an adsorption process. The cited prior art references have completely mis-characterized the process of adsorption in that none of the cited references are involved in removing a soluble contaminant from solution. None of the cited prior art process are adsorption processes.

The misuse and confusion of the term adsorption in the cited prior art is made even more apparent by the fact that the Sato et al. reference, in the "Field of the Invention" section, at Col. 1, lines 1-2 states, "The present invention relates to an oil-absorbing material for treating oil-contaminated water ..." and in the "Summary of the Invention" section, at Col.1, lines 46-50, states, "An object of the present invention is to provide an oil-adsorbing material for treating oil-contaminated water, which can remove not only floating oil and suspended dispersed oil, but also stably emulsified dispersed oil." To one of ordinary skill in the art this latter statement that combines the term adsorption with the removal of insoluble contaminants from a fluid is an oxymoron. The second quotation from Sato et al., which indicates that the object of the invention is directed to oil-contaminated water such as "floating oil and suspended oil, but also stably

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emulsified dispersed oil," clearly indicates that <u>Sato</u> is <u>not</u> directed to the removal of soluble contaminants.

Importantly, <u>Sato et al.</u> in its solitary mention of soluble contaminants <u>admits</u> that the process of <u>Sato et al.</u> does not apply to the removal of soluble contaminants. At Col. 4, lines 29-36, <u>Sato et al.</u> states that when dealing with contaminated water that has a "completely water-soluble COD (chemical oxygen demand) load" the technique of <u>Sato et al.</u> can be first used to remove the oil from the water **but** the removal of the soluble contaminant must be done by subsequently using the "conventional adsorption treatment with activated carbon." Thus <u>Sato et al.</u>, when faced with a soluble contaminate, <u>admits that its</u> own invention is only of value to remove the emulsified oil and the soluble contaminate must be removed by other means. This admission by <u>Sato et al.</u> is completely consistent with the remainder of the <u>Sato et al.</u> disclosure, which is directed solely to removing floating oil, suspended oil, and/or emulsified dispersed oil. Therefore, <u>Sato</u> does <u>not</u> teach an adsorption method consistent with the meaning of adsorption as understood by one of ordinary skill in the art.

One of ordinary skill in the art, familiar with the complete definition of adsorption would correctly recognize that <u>Sato et al.</u> does not teach the removal of soluble contaminants from solution; it does not teach the removal of a solid from its solution and depositing the solid on the surface of an adsorbent; it <u>does not</u> teach adsorption. Because the <u>Sato et al.</u> reference is directed to absorption and the removal of insoluble contaminants only, it is inapplicable to the invention as consistently claimed by the Applicants.

This shortcoming of <u>Sato et al.</u> is common to all of the cited references in the Official Action. The only contaminants described as being removed by the processes described in those references are insolvent contaminants, contaminants that are free, in a separate phase, or emulsified in the contaminated fluid. None of the references disclose an adsorption process for

the removal of soluble contaminants from solution. As such, none of the cited references are applicable to the Applicants claimed invention.

A term of art, such as "adsorption," which is well known to those of ordinary skill in the art, should not lose its true meaning and should not have a mischaracterization of the term imposed on a patent applicant simply because prior art has been found and cited that misuses the term. While each of patentees of the cited prior art had license to be their own lexicographer in drafting their respective patents, their errors of word usage cannot be imposed on one of ordinary skill in the art who subsequently uses the same term correctly. The present application, as claimed and as argued by the Applicants from the beginning of prosecution is drawn to an adsorption process wherein the spent adsorbent is removed from the column and subsequently composted so as to reduce the volume of the spent adsorbent and so as to concentrate the removed contaminant. In contrast, the cited prior art clearly discloses only the process of absorption directed to the removal of insolvent contaminants.

Applicants' amendment to Claim 1 raises no new issues to the present patent prosecution but has been submitted solely to make the distinction between the claimed adsorption process and the cited prior art as clear as possible. All earlier arguments related to the present rejection remain valid and are herein incorporated by reference.

Additionally, Applicants would like to point out that in response to the Examiner's Election of Species Requirement dated November 28, 2002, the contaminant TNT (a soluble contaminant) was elected. To date, none of the references cited by the Examiner in the present or past Official Actions have addressed the removal of the elected species, TNT from a solution. Thus, while the issue of a soluble contaminant is not new to the prosecution of the present application, no prior art directed to the removal of a soluble contaminant from solution, and particularly directed to the elected species of contaminant (TNT) has been found and cited in the

present case. As such, Applicants respectfully assert that a rejection of the elected species has yet to be made of record in the present application.

In view of the above, Applicants respectfully submit that the present rejection of the claims is overcome. Accordingly withdrawal of the rejection is respectfully requested.

CONCLUSION

In light of the above, Applicants believe that this application is now in condition for allowance and therefore requests favorable consideration.

If any points remain in issue which the Examiner feels may be best resolved through a personal or telephonic interview, the Examiner is respectfully requested to contact the undersigned at the telephone number listed below.

Respectfully submitted,

PIPER RUDNICK LLP

Steven B. Kelber
Registration No. 30,073
Attorney of Record

1200 Nineteenth Street, N.W.   Perry E. Van Over
Washington, D.C. 20036-2412   Registration No. 42,197
Telephone No. (202) 861-3900
Facsimile No. (202) 223-2085

ATTACHMENT (1)

Amendment After Final

Adsorption Phenomena

What is adsorption? ● Adsorbents ● Applications ● References

IAS Home Page

What is adsorption?

The use of solids for removing substances from either gaseous or liquid solutions has been widely used since biblical times. This process, known as *adsorption*, involves nothing more than *the preferential partitioning of substances from the gaseous or liquid phase onto the surface of a solid substrate*. From the early days of using bone char for decolorization of sugar solutions and other foods, to the later implementation of activated carbon for removing nerve gases from the battlefield, to today's thousands of applications, the adsorption phenomenon has become a useful tool for purification and separation.

Adsorption phenomena are operative in most natural physical, biological, and chemical systems, and adsorption operations employing solids such as activated carbon and synthetic resins are used widely in industrial applications and for purification of waters and wastewaters.

The process of adsorption involves separation of a substance from one phase accompanied by its accumulation or concentration at the surface of another. The adsorbing phase is the adsorbent, and the material concentrated or adsorbed at the surface of that phase is the adsorbate. Adsorption is thus different from absorption, a process in which material transferred from one phase to another (e.g. liquid) interpenetrates the second phase to form a "solution". The term sorption is a general expression encompassing both processes.

Physical adsorption is caused mainly by van der Waals forces and electrostatic forces between adsorbate molecules and the atoms which compose the adsorbent surface. Thus adsorbents are characterized first by surface properties such as surface area and polarity.

A large specific surface area is preferable for providing large adsorption capacity, but the creation of a large internal surface area in a limited volume inevitably gives rise to large numbers of small sized pores between adsorption surfaces. The size of the micropores determines the accessibility of adsorbate molecules to the internal adsorption surface, so the pore size distribution of micropores is another important property for characterizing adsorptivity of adsorbents. Especially materials such as zeolite and carbon molecular sieves can be specifically engineered with precise pore size distributions and hence tuned for a particular separation.

Surface polarity corresponds to affinity with polar substances such as water or alcohols. Polar adsorbents are thus called "hydrophillic" and aluminosilicates such as zeolites, porous alumina, silica gel or silica-alumina are examples of adsorbents of this type. On the other hand, nopolar adsorbents are generally "hydrophobic". Carbonaceous adsorbents, polymer adsorbents and silicalite are typical nonpolar adsorbents. These adsorbents have more affinity with oil or hydrocarbons than water.

Text adapted from:

Slejko, F.L., *Adsorption Technology*, Marcel Dekker, New York, 1985
M. Suzuki, *Adsorption Engineering*, Elsevier,Amsterdam, 1990

More <u>information on adsorption</u> related subjects through the links page.

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Adsorbents

The adsorbent is the separating agent used to express the difference between molecules in a mixture: adsorption equilibrium or kinetics.

Microporous, high specific surface material (200 - 2000 m2/g)

Most commonly used:

Alumina (drying)

Silicagel (drying)

Zeolite molecular sieves (gas & liquid separations, drying)
    highly specific, single pore size
    may be fine-tuned: cations + structure
    A type or LTA
    X and Y or FAUjasites
    Mordenite, other natural zeolites
    Silicalites or ZSMx (hydrophobic, carbon like)

Active carbon (gas & liquid separations, guard beds)

Carbon molecular sieves (narrow pore distribution)

Others:

    impregnated carbons (Cu-chlorides - CO separation)
    clays (natural and pillared clays)
    resins, polymers (biological, ions, large molecules)

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Applications

Representative Commercial Gas Phase Adsorption Separation

Gas Bulk Separations (b)	
Separation (a)	Adsorbent
Normal paraffins, isoparaffins, aromatics	Zeolite
N2/O2	Zeolite
O2/N2	Carbon molecular sieve
CO, CH4, CO2, N2, A, NH3/H2	Zeolite, activated carbon
Acetone/vent streams	Activated carbon
C2H4/vent streams	Activated carbon
H2O/ethanol	Zeolite
Gas Purifications (c)	
Separation (a)	Adsorbent
H2O/olefin-containing cracked gas, natural gas, air, synthesis gas, etc...	Silica, alumina, zeolite
CO2/C2H4, natural gas, etc.	Zeolite
Organics/vent streams	Activated carbon, others
Sulfur compounds/natural gas, hydrogen, liquified petroleum gas (LPG), etc.	Zeolite
Solvents/air	Activated carbon
Odors/air	Activated carbon
NOx/N2	Zeolite
SO2/vent streams	Zeolite
Hg/chlor-alkali cell gas effluent	Zeolite

a Adsorbates listed first
b Adsorbate concentrations of about 10 wt. % or higher in the feed
c Adsorbate concentrations generally less than about 3 wt.% in the feed.

Representative Commercial Liquid Phase Adsorption Separations

Liquid Bulk Separations (b)	
Separation (a)	Adsorbent
Normal paraffins / isoparaffins, aromatics	Zeolite
p-Xylene/o-xylene, m-xylene	Zeolite
Detergent-range olefins/paraffins	Zeolite
p-Diethyl benzene/isomer mixture	Zeolite
Fructose /glucose	Zeolite
Liquid Purifications (c)	
Separation (a)	Adsorbent
H2O/organics, oxygenated organics, chlorinated organics, etc.	Silica, alumina, zeolite
Organics, oxygenated organics, chlorinated organics, etc./H2O	Activated carbon

Odor, taste bodies/drinking H2O	Activated carbon
Sulfur compounds/organics	Zeolite, others
Various fermentation products/fermentor effluent	Activated carbon
Decolorizing petroleum fractions, sugar syrups, vegetable oils, etc.	Activated carbon

a Adsorbates listed first
b Adsorbate concentrations of about 10 wt. % or higher in the feed
c Adsorbate concentrations generally less than about 3 wt.% in the feed.

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A few references on the subject

This random list is by no means complete and just as a start in this still strongly evolving subject.

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John Wiley & Sons, New York, 1984

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Vol.I-Applications in Industry,1061 pages
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Elsevier, Amsterdam 1999

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F. Rouquerol, J. Rouquerol and K SIng
Academic Press, 1999

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ATTACHMENT (2)

Amendment After Final

Chemical Engineers' Handbook

FIFTH EDITION

Prepared by a staff of specialists
under the editorial direction of

Robert H. Perry
Consultant

Cecil H. Chilton
Senior Advisor
Battelle Memorial Institute

face in a vaporization-type crystallizer.

High levels of supersaturation at the liquid surface or at the tube walls in a surface-cooled crystallizer are the dominant cause of wall salting. Although some types of crystallizers can operate for several months continuously when crystallizing KCl or $(NH_4)_2SO_4$, most machines have much shorter operating cycles. Second only to control of particle size, *the extension of operating cycles is* the most difficult operating problem to be solved in most installations.

In the *forced-circulation-type crystallizer* (Fig. 19-40) the primary control over particle size is exercised by the designer in selecting the circulating system and volume of the body. From the operating standpoint there is little that can be done to an existing unit other than supply external seed, classify the discharge crystals, or control the slurry density. Nevertheless, machines of this type are frequently carefully controlled by these techniques and produce a predictable and desirable product-size distribution.

When crystals cannot be grown sufficiently large in forced-circulation equipment to meet product-size requirements, it is common to employ one of the designs that allow some influence to be exercised over the population density of the finer crystals. In *the DTB design* (Fig. 19-42) this is done by regulating the flow in the circulating pipe so as to withdraw a portion of the fines in the body in the amount of about 0.05 to 0.5 per cent by settled volume. The exact quantity of solids depends on the size of the product crystals and on the capacity of the fines-dissolving system. If the machine is not operating stably, this quantity of solids will appear and then disappear, indicating changes in the nucleation rate within the circuit. At steady-state operation, the quantity of solids overflowing will remain relatively constant, with some solids appearing at all times. Should the slurry density of product crystals circulated within the machine rise to a value higher than about 50 per cent settled volume, large quantities of product crystals will appear in the overflow system, disabling the fines-destruction equipment. Too high a circulating rate through the fines trap will produce this same result. Too low a flow through the fines circuit will remove insufficient particles and result in a smaller product-size crystal. To operate effectively, a crystallizer of the type employing fines-destruction techniques requires more sophisticated control than does operation of the simpler forced-circulation equipment.

The classifying crystallizer (Fig. 19-45) requires approximately the same control of the fines-removal stream, and in addition requires control of the fluidizing flow circulated by the main pump. This flow must be adjusted to achieve the proper degree of fluidization in the suspension chamber, and this quantity of flow varies as the crystal size varies between start-up operation and normal operation. As with the draft-tube-baffle machine, a considerably higher degree of skill is required for operation of this equipment than of the forced-circulation type.

While most of the industrial designs in use today are built to reduce the problems due to excess nucleation, it is true in some crystallizing systems that a deficiency of seed crystal is produced and the product crystals are larger than are wanted or required. In such systems nucleation can be increased by increasing the mechanical stimulus created by the circulating device or by seeding through the addition of fine crystals from some external source.

CRYSTALLIZER COSTS

Because crystallizers can come with such a wide variety of attachments, capacities, materials of construction, and designs, it is very difficult to present an accurate picture of the costs for any except certain specific types of equipment. crystallizing specific compounds. Figure 19-48 shows equipment costs per unit rate of production for two compounds, but it should be ever present in the reader's mind that the manufacturers should be consulted in any specific case. Most crystallization equipment is custom designed, and costs for a particular application may vary greatly from those illustrated in Fig. 19-48.
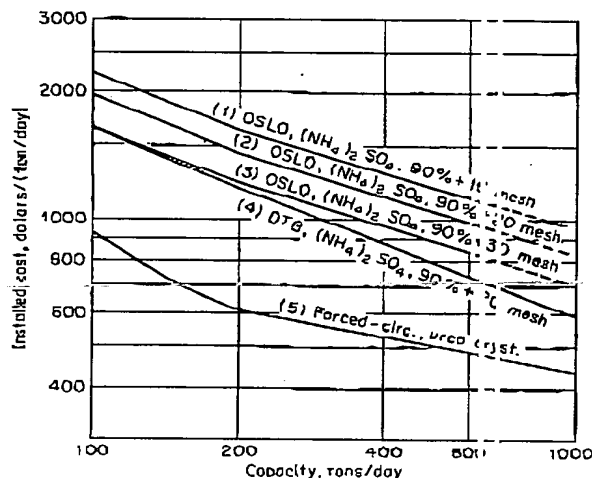
p. 19-33

ION-EXCHANGE AND ADSORPTION EQUIPMENT

REFERENCES: Abrams, "Color Removal from Sugar Solutions by Adsorbent Resins," paper presented at American Chemical Society, 157th National Meeting, Minneapolis, Apr. 15, 1969. Applebaum, "Demineralization by Ion Exchange," Academic, New York, 1968. Arden, "Water Purification by Ion Exchange," Plenum Press, New York, 1968. Gilwood, *Chem. Eng.,* 74(26), 83 (1967). Hiester, Cohen, and Phillips, *Chem. Eng. Progr. Symp. Ser.,* 50(14), 23, 51, 83 (1954). Kuryea, "Externally Regenerated Condensate Demineralization Systems for Once-through Steam Generators," Liberty Bell Corrosion Course, National Association of Corrosion Engineers and Drexel Institute of Technology, Philadelphia, Pa., Sept. 16-18, 1969. Michalson and Reents, *Proc. 28th Intern. Water Conf., Engrs. Soc. West. Penn.* (December, 1967). Nachod and Schubert, "Ion Exchange Technology," Academic, New York, 1956. Nordell, "Water Treatment for Industrial and Other Uses," Reinhold, New York, 1961. Roberts, Developments in Continuous Ion Exchange Equipment for AEC Applications, Oak Ridge Natl. Lab. Rept.

ORNL-2504, May 21, 1958. Thompson and Reents, *Proc. Ann. Power Conf.,* 21, 699 (1959).

Introduction. Operations that involve sorptive mass transfer between a liquid and the active surface of a solid are an important means of liquid purification, dissolved-solute recovery, and solute separation. In general there are two broad classes of such operations: (1) ion exchange, in which a layer of free ions, held on a resinous sorbent by bound groups in the sorbent carrying the opposite charge, can be displaced by other ions of the same charge; (2) adsorption, in which solute molecules are attracted to vacant active sites on the surface of a microcrystalline or resinous sorbent, condensing on these sites by virtue of the action of physical forces or
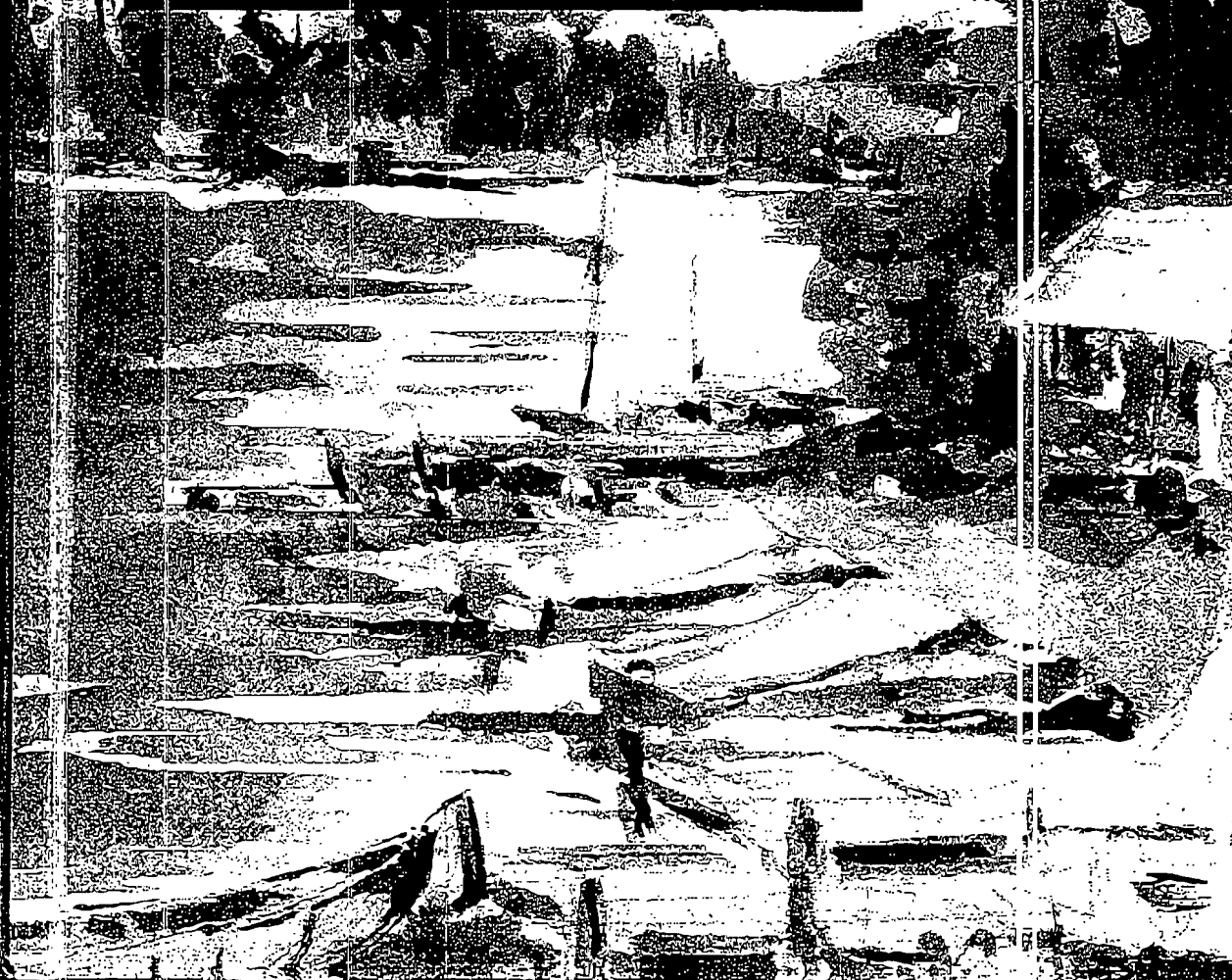
ATTACHMENT (3)

Amendment After Final

McGraw-Hill Series in Water Resources and Environmental Engineering

Introduction to

Environmental Engineering

Third Edition

Davis • Cornwell

Advanced Oxidation Processes (AOPs)

AOPs are combinations of disinfectants designed to produce hydroxyl radicals (OH·). Hydroxyl radicals are highly reactive nonselective oxidants able to decompose many organic compounds. Most noteworthy of the AOP processes is ozone plus hydrogen peroxide.

3-9 ADSORPTION

Adsorption is a mass transfer process wherein a substance is transferred from the liquid phase to the surface of a solid where it is bound by chemical or physical forces

Generally, in water treatment, the adsorbent (solid) is activated carbon, either granular (GAC) or powdered (PAC). PAC is fed to the raw water in a slurry and is generally used to remove taste- and odor-causing substances or to provide some removal of synthetic organic chemicals (SOCs). GAC is added to the existing filter system by replacing the anthracite with GAC, or an additional contactor is built and is placed in the flow scheme after primary filtration. The design of the GAC contactor is very similar to a filter box, although deeper.

At present, the applications of adsorption in water treatment in the United States are predominately for taste and odor removal. However, adsorption is increasingly being considered for removal of SOCs, VOCs, and naturally occurring organic matter, such as THM precursors and DBPs.

Biologically derived earthy-musty odors in water supplies are a widespread problem. Their occurrence interval and concentration vary greatly from season to season and is often unpredictable. As mentioned, one of the most popular methods for removing these compounds is the addition of PAC to the raw water. The dose is generally less than 10 mg/L. The advantage of PAC is that the capital equipment is relatively inexpensive and it can be used on an as-needed basis. The disadvantage is that the adsorption is often incomplete. Sometimes even doses of 50 mg/L are not sufficient.

As an alternative for taste and odor control, many plants have replaced the anthracite in the filters with GAC. The GAC will last from one to three years and then must be replaced. It is very effective in removing many taste and odor compounds.

Concern about SOCs in drinking water has motivated interest in adsorption as a treatment process for removal of toxic and potentially carcinogenic compounds present in minute, but significant, quantities. Few other processes can remove SOCs to the required low levels. Generally, GAC is used for SOC removal either as a filter media replacement or as a separate contactor. The data for how long the GAC will last for any given SOC are somewhat limited and must be evaluated on a case-by-case basis. If the GAC is designed to remove SOCs from a periodic "spill" into the source water, then filter media replacement may be adequate because the GAC is not being used every day and is acting as a barrier. However, if the GAC is to be used continuously for SOC removal, then a separate contactor may be warranted.

GAC has been proposed to be used to remove naturally occurring organic matter that would, in turn, reduce the formation of DBPs, particularly THMs. Testing has shown that GAC will remove these organics. It must operate in a separate

ATTACHMENT (4)

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GRANULAR ACTIVATED CARBON
FOR WATER & WASTEWATER TREATMENT

INTRODUCTION

Carbon has been used as an adsorbent for centuries. Early uses of carbon were reported for water filtration and for sugar solution purification. Activated carbons ability to remove a large variety of compounds from contaminated waters has led to its increased use in the last thirty years. Recent changes in water discharge standards regarding toxic pollutants has placed additional emphasis on this technology.

ADSORPTION

Adsorption is a natural process by which molecules of a dissolved compound collect on and adhere to the surface of an adsorbent solid. Adsorption occurs when the attractive forces at the carbon surface overcome the attractive forces of the liquid.

Granular activated carbon is a particularly good adsorbent medium due to its high surface area to volume ratio. One gram of a typical commercial activated carbon will have a surface area equivalent to 1,000 square meters. This high surface area permits the accumulation of a large number of contaminant molecules.

ADSORPTION CAPACITY

The specific capacity of a granular activated carbon to adsorb organic compounds is related to: molecular surface attraction, the total surface area available per unit weight of carbon, and the concentration of contaminants in the wastewater stream.

The basic instrument for evaluating activated carbon use is the adsorption isotherm. The isotherm represents an empirical relationship between the amount of contaminant adsorbed per unit weight of carbon and its equilibrium water concentration.

This relationship can be expressed in the form:

$$X/M = KC^{1/n}$$

where:

X/M	=	Amount of contaminant adsorbed per unit weight of carbon
C	=	Concentration of contaminant in the water stream
K,n	-	Empirical constants particular to the contaminant

The constants K and n are determined by plotting experimental results on log-log paper with the concentration of contaminant on the X axis and the amount of contaminant adsorbed on the y axis. The slope of the line developed is equal to $1/n$ and the intercept equal to K. These dimensionless empirical constants are useful for comparing the adsorption capacities for different compounds or for assessing the adsorption capacities of various activated carbons.

Liquid phase adsorption isotherms have been developed for most commercial activated carbons for a variety of specific compounds. Figure I presents a typical adsorption isotherm used to predict activated carbon adsorption capacity. An isotherm is specific to a particular contaminant and the type of activated carbon used.

ATTACHMENT (5)

Amendment After Final

WEBSTER'S DESK DICTIONARY

The most complete, comprehensive and
compact dictionary for school and office

é-mi-gré (em'i grā'; em'i grā'), n., pl. -grés. an emigrant. esp. one who flees for political reasons.

em-i-nence (em'o nəns), n. 1. high station, rank, or repute. 2. a high place; hill or height. 3. (cap.) a title of honor applied to cardinals.

em'i-nent, adj. 1. high in station, rank or repute; distinguished. 2. lofty; high. 3. prominent; conspicuous. —em'i-nent-ly, adv.

em'inent domain', n. the power of the state to take private property for public use.

e-mir (e mēr', ā mēr'), n. a chieftain, prince, commander, or head of state in some Islamic countries. —em-i-rate (em'ər it, ə mēr'-), n.

em-is-sar-y (em'ə ser'ē), n., pl. -ies. a representative sent on a mission, esp. a secret mission.

e-mit (i mit'), v.t., e-mit-ted, e-mit-ting. 1. to send forth; discharge: a bonfire emitting heat. 2. to utter; voice. 3. to issue formally, as paper money. —e-mis-sion (i mish'ən), n. —e-mit'ter, n.

e-mol-lient (i mol'yənt), adj. 1. softening or soothing: an emollient lotion for the skin. —n. 2. an emollient substance.

e-mol-u-ment (i mol'yə mənt), n. compensation, as fees, from employment; recompense.

e-mote (i mōt'), v.i., e-mot-ed, e-mot-ing. to show emotion in or as if in acting. —e-mot'er, n.

e-mo-tion (i mō'shən), n. 1. a strong feeling, as joy, sorrow, hate, or love. 2. strong agitation or excitement. —e-mo'tion-al, adj. —e-mo'tion-al-ism, n. —e-mo'tion-al-ly, adv.

em-pa-thize (em'pə thīz'), v.i., -thized, -thiz-ing. to experience empathy.

em'pa-thy (-thē), n. identification with or vicarious experiencing of the feelings or thoughts of another. —em-pa-thet-ic (-thet'ik), adj.

em-per-or (em'pər ər), n. the male ruler of an empire.

em-pha-sis (em'fə sis), n., pl. -ses (-sēz'). 1. special stress or importance: an emphasis on reliability. 2. stress given to particular words or syllables.

em-pha-size (-sīz'), v.t., -sized, -siz-ing. to give emphasis to; stress.

em-phat-ic (-fat'ik), adj. 1. uttered or done with emphasis. 2. using emphasis in speech or action. —em-phat'i-cal-ly, adv.

em-phy-se-ma (em'fə sē'mə, -zē'-), n. a chronic lung disease characterized by abnormal enlargement and loss of elasticity of the air spaces.

em-pire (em'pīr), n. 1. a group of nations, states, or peoples ruled over by a powerful sovereign, esp. an emperor or empress. 2. sovereignty; dominion. 3. a powerful enterprise controlled by one person or group: a shipping empire. [< AF, OF < L imperium]

em-pir-i-cal (em pir'i kəl), adj. derived from or depending upon experience or observation alone. —em-pir'i-cal-ly, adv.

em-pir-i-cism (-siz'əm), n. 1. empirical method or practice. 2. the philosophic doctrine that all knowledge is derived from sense experience. —em-pir'i-cist, n., adj.

em-place-ment, n. a space or platform where heavy military equipment, esp. artillery, can be positioned.

em-ploy (em ploi'), v.t. 1. to engage the services of; hire. 2. to make use of. 3. to devote (time, energies, etc.) to a particular activity. —n. 4. employment; service. —em-ploy'a-ble, adj. —em-ploy'er, n.

em-ploy-ee or -ploy-e (-ploi'ē), n. a person hired to work for another.

em-ploy'ment, n. 1. the act of employing or state of being employed. 2. an occupation or activity.

em-po-ri-um (em pôr'ē əm), n., pl. -po-ri-ums, -po-ri-a (-pôr'ē ə), a retail store selling a great variety of articles.

em-pow'er, v.t. 1. to give power or authority to. 2. to enable. —em-pow'er-ment, n.

em-press (em'pris), n. 1. a female ruler of an empire. 2. the consort of an emperor.

emp-ty (emp'tē), adj., -ti-er, -ti-est, v., -tied, -ty-ing, n., pl. -ties. —adj. 1. containing nothing. 2. not occupied; vacant. 3. lacking force, effect, or significance. —v.t., v.i. 4. to make or become empty. 5. to discharge: The river empties into the sea. —n. 6. an empty container. —emp'ti-ly, adv. —emp'ti-ness, n.

emp'ty-hand'ed, adj. 1. having nothing in the hands. 2. having achieved nothing.

emp'ty nest' syn'drome, n. a depressed state felt by some parents after their children have grown up and left home.

em-py-re-an (em'pə rē'ən, -pī'-), n. 1. the highest heaven. 2. the visible heavens; sky.

EMT, emergency medical technician.

e-mu (ē'myōo), n., pl. e-mus. a large, flightless bird of Australia that resembles the ostrich.

EMU or emu, electromagnetic unit.

em-u-late (em'yə lāt'), v.t., -lat-ed, -lat-ing. to imitate in an effort to equal or surpass. —em'u-la'tion, n. —em'u-la'tive, adj. —em'u-la'tor, n.

e-mul-si-fy (i mul'sə fī'), v.t., v.i., -fied, -fy-ing. to make into or form an emulsion. —e-mul-si-fi-ca'tion, n. —e-mul'si-fi'er, n.

e-mul-sion (-shən), n. 1. a colloidal suspension of one liquid in another. 2. a photosensitive coating on photographic film.

en (en), n. a space that is half the width of an em.

en-, a prefix meaning: to put in to or on (enthrone); to cover or surround with (enfold); to make or cause to be (enlarge).

-en[1], a suffix meaning: to make or become (harden); to cause or come to have (strengthen).

-en[2], a suffix meaning made of or resembling (wooden).

en-a-ble (en ā'bəl), v.t., -bled, -bling. 1. to make able; authorize or empower. 2. to make possible or easy. —en-a'bler, n.

en-act', v.t. 1. to make into a law. 2. to represent in or as if in a play. —en-act'ment, n.

e-nam-el (i nam'əl), n., v., -eled, -el-ing or (esp. Brit.) -elled, -el-ling. —n. 1. an ornamental or protective glassy substance, usu. opaque, applied by fusion to the surface of metal, pottery, etc. 2. a paint that dries to a hard, glossy finish. 3. the hard glossy covering of the crown of a tooth. —v.t. 4. to inlay or overlay with enamel. —e-nam'el-er, n.

e-nam'el-ware', n. metal utensils covered with enamel.

en-am-or (i nam'ər), v.t. to fill or inflame with love: He was enamored of the princess. Also, esp. Brit. en-am'our.

en bloc (än blôk'), adv., adj. French. as a whole; all together.

en-camp', v.t., v.i. to lodge or settle in a camp. —en-camp'ment, n.

en-cap-su-late (en kap'sə lāt', -syoo-), v.t., -lat-ed, -lat-ing. 1. to place in or as in a capsule. 2. to summarize or condense. —en-cap'su-la'tion, n.

en-case', v.t., -cased, -cas-ing. to enclose in or as if in a case.

-ence, a suffix meaning: act or state (abhorrence); state or quality (absence).

en-ceph-a-li-tis (en sef'ə lī'tis), n. inflammation of the brain. —en-ceph'a-lit'ic -lit'ik), adj.

en-ceph-a-lon (-lon', -lən), n., pl. -lons, -la (-lə), the brain.

en-chain', v.t. to bind with or tie up with chains; fetter.

en-chant (en chant', -chänt'), v.t. 1. to place under a spell; bewitch. 2. to delight utterly; captivate. —en-chant'er, n. —en-chant'ing-ly, adv. —en-chant'ment, n.

en-chi-la-da (en'chə lä'də, -nē'ə), n., pl. -das. a tortilla rolled around a filling, as of meat or cheese, served usu. with a chili-flavored sauce.

en-ci-pher, v.t. to put (a message) into cipher. —en-ci'pher-ment, n.

en-cir'cle, v.t., -cled, -cling. 1. to form a circle around. 2. to make a circuit of. —en-cir'cle-ment, n.

encl. 1. enclosed. 2. enclosure.

en-clave (en'klāv, än'-), n. a country or a portion of a country surrounded by foreign territory.

en-close' (-klōz'), v.t., -closed, -clos-ing. 1. to shut or hem in on all sides. 2. to surround, as with a fence. 3. to insert in the same envelope or package with something else. —en-clo'sure, n.

en-code', v.t., -cod-ed, -cod-ing. to convert (a message, etc.) into code. —en-cod'er, n.

en-co-mi-um (en kō'mē əm), n., pl. -mi-ums, -mi-a (-mē ə). a usu. formal expression of high praise.

en-com-pass (en kum'pəs), v.t. 1. to encircle; surround. 2. to enclose; envelop. 3. to include comprehensively.

en-core (äng'kôr, än'-), n., v., -cored, -cor-ing. —n.

ATTACHMENT (6)

Amendment After Final

Chemical Engineers' Handbook

FIFTH EDITION

Prepared by a staff of specialists
under the editorial direction of

Robert H. Perry
Consultant

Cecil H. Chilton
Senior Advisor
Battelle Memorial Institute

McGRAW-HILL BOOK COMPANY

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Gas Agitation. The gas may be a vapor such as steam which is generated in place by boiling the liquids to be contacted, or which may be admitted through spargers at the bottom of the vessel.

Permanent gases such as air may also be used. Air, for example, has been used extensively for the mixing of reagents such as sulfuric acid with all but the most volatile of petroleum liquids. It can provide the gentlest of agitation, as in the washing of nitroglycerin with water, as well as vigorous mixing. There is danger of oxidation of product with air, and with any gas there will necessarily be some volatilization of the liquids being mixed. Gas agitation in the extraction of radioactive liquids offers the advantages of no maintenance-requiring moving parts, but it may require decontamination of the effluent air.

Although gas agitation has usually been considered an uneconomical method of applying mixing power, there is little in the way of quantitative data with which to judge its effectiveness in contacting immiscible liquids. Mathers and Winter [*Can. J. Chem. Eng.*, 37, 99 (1959)] describe a mixer-settler in which air is used as an air-lift type of mixer. With a mixer of 5 liters volume, aqueous acetic acid (3.48 liters/min.) was extracted with hexone (6.9 liters/min.), using 0.3 cu. ft./min. of air. The average stage efficiency (including the effect of a 10-liter settler) was $E_{MR} = 0.93$, and the power for air was 0.001 hp., corresponding to 90 ft.-lb. energy expended/cu. ft. liquids treated. Thornton [*Nucl. Eng.*, 1, 156, 204 (1956)] describes a somewhat similar air-agitated mixer.

Settlers

Emulsions and Dispersions. The mixture of liquids issuing from a mixer is a form of emulsion which must be settled, coalesced, and separated into its constituent liquid phases in bulk in order to withdraw the separated liquids from a stage. In order for a dispersion to "break" into its separate phases in bulk, both sedimentation and coalescence of the drops of the dispersed phase must occur. Permanent or stable emulsions are those whose droplets of dispersed phase are so small that settling and coalescence take place only over long periods of time, if at all. They are characterized by particle diameters of the order of 1 to 1.5 μ or less. Unstable or temporary emulsions, or dispersions, whose particle diameters are of the order of 1 mm. or larger, usually settle rapidly. Only the latter kind are tolerable in liquid-extraction operations and in conducting two-liquid chemical reactions where the phases are ultimately to be separated. Emulsions and dispersions are usually

characterized by the terms water-in-oil (meaning an aqueous liquid dispersed, organic continuous) and oil-in-water (organic dispersed, aqueous continuous). Dual emulsions are those where the continuous phase is also present as very small drops dispersed within larger drops of the other liquid. See Becher, "Emulsions, Theory and Practice," A.C.S. Monograph 175, Reinhold, New York, 1957.

Meissner and Chertow [*Ind. Eng. Chem.*, 38, 856 (1946)] show that the "breaking" of a dispersion under undisturbed batch conditions may be divided into two periods: (1) primary break, or rapid settling and coalescence of the bulk of the dispersed phase, which usually leaves a fog or haze of very small droplets suspended in dilute concentration in the majority liquid; and (2) secondary break, which represents the slow settling of the fog. For most purposes of multistage extraction, settlers designed for the slow secondary break would be too large; the small amount of interstage entrainment represented by the secondary fog hardly influences stage efficiency. For purposes of conserving solvent, however, it may be necessary to clarify as completely as possible the effluent from the final stage of a cascade. The use of coalescers (see below) can frequently eliminate the secondary fog.

Sedimentation. There are inadequate data on the settling of clouds of liquid drops through a liquid medium. Very small, isolated drops, settling in stagnant liquids under the force of gravity, move more rapidly than solid spheres. It is known that settling of dispersions is more rapid the larger the drop size and density difference, and the smaller the continuous-phase viscosity. This is confirmed by Eclix and Holder [*A.I.Ch.E. J.*, 1, 226 (1955)] in the case of petroleum-oil dispersions in water and phero, who show also the reduced settling time required if the continuous-phase viscosity is decreased by increasing the temperature.

Coalescence. The principal driving force for coalescence of the settled drops is interfacial tension, which must be large if coalescence is to be rapid. Stabilizing agents or surfactants, which lower interfacial tension, lower the rate of coalescence and may also interfere by increasing the surface viscosity of the drops [see, for example, Nielsen, Wall, and Adams, *J. Colloid Sci.*, 13, 441 (1958)]. Finely divided solids tend to accumulate at liquid interfaces and also retard coalescence thereby.

Gravity Settlers, Decanters. These are tanks wherein the dispersion is continuously settled and coalesced, and from which the settled liquids are continuously withdrawn. There is no well-established shape or best arrangement. Figure 21-11 shows some typical settlers. See also Treybal ("Liquid Extraction," 2d ed.,
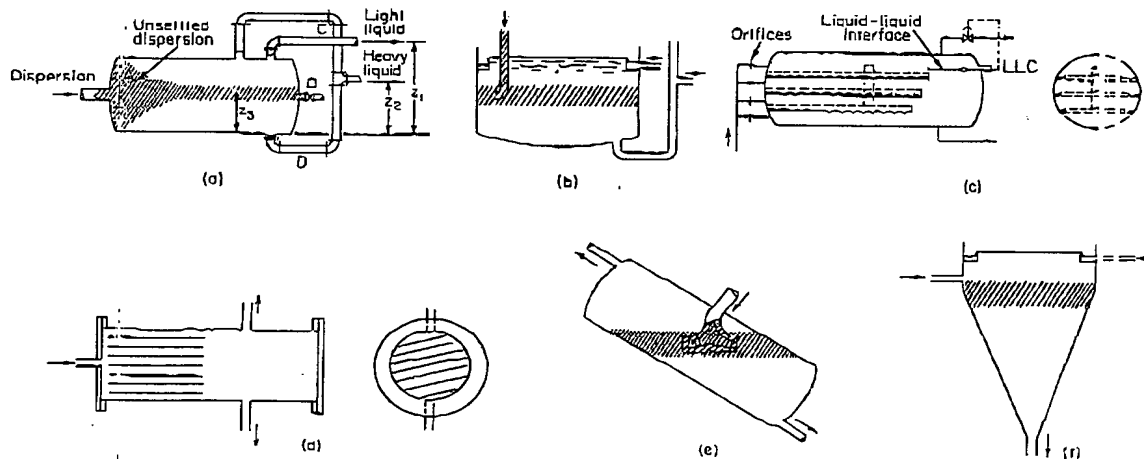

(a)   (b)   (c)

(d)   (e)   (f)

Fig. 21-11. Gravity settlers (schematic). (a) Simple horizontal decanter. (b) Vertical decanter. [*Ryon et al., Chem. Eng. Progr.*, 55(10), 70 (1959).] (c) Baffled. [*Morello and Poffenberger, Ind. Eng. Chem.*, 42, 1020 (1950), with permission.] (d) Baffled. [*Brutis and Kirkbride, Trans. Am. Inst. Chem. Engrs.*, 42, 413 (1946).] (e) *Edeleanu et al.* (U.S. Patent 1,666,560, 1928.) (f) Cone-bottom. [*Shaw and Long, Chem. Eng.*, 64(11), 251 (1957).]